

An Exponential Spiral Antenna

This no-tune antenna for 160 to 10 meters won third place in the 80 through 10 meters category of the 2024 QST Antenna Design Competition.

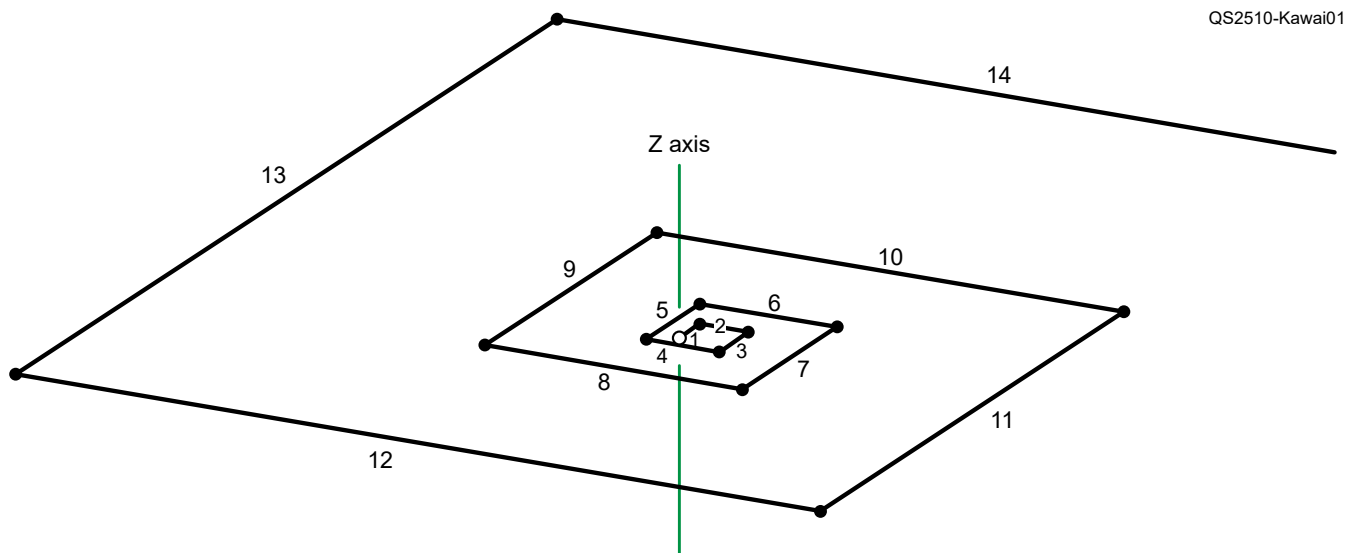


Figure 1 — Layout of wire segments 1 through 14.

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This antenna is designed to operate across all HF bands without requiring tuning, and it has some circular polarization. For wide bandwidth, it's necessary to employ antenna structures such as self-complementary or traveling-wave types. Because I thought it would be easier to build without a terminating resistor, I considered a helical- or spiral-type design. A circular- or polygonal-shaped foundation would make the design more complex, so I opted for a shape based on a quadrilateral. If constructed at a constant height, it becomes a spiral antenna, and if the height gradually increases, it forms a helical antenna. I chose a simple spiral design. Because bifilar spiral antennas are difficult to construct, I opted for a single-wire design working against the ground. The antenna's gain was not a priority, and I considered a level of around 0 dBi to be acceptable.

To achieve broadband characteristics, the length of each element is adjusted exponentially. The 14-element configuration uses a base of 1.34 for the exponential adjustment, ensuring the longest element is approximately 45 meters (17 feet). By calculating $L_1 = 1$, $L_2 = 1.34$, $L_3 = (1.34)^2$, $L_4 = (1.34)^3$, and so on, you can easily determine the lengths using spreadsheet software like *Excel* (see Table 1 and Figure 1).

In practice, the 90-degree angles and element lengths differ slightly from the calculated values, as guy wires are secured using existing trees or buildings.

I used stainless-steel stranded wire with a diameter of 1 millimeter for the antenna elements. This type of wire is lightweight, durable, and unobtrusive. Additionally, when purchasing from Amazon or similar online retailers, you often receive figure-eight-shaped crimping sleeves, which are very convenient. Be sure to use sharp pliers when cutting stainless-steel wire so you get a clean cut. Otherwise, threading the wire through the holes of the figure-eight-shaped crimping	10	13.9	45.7
	11	18.7	61.2
	12	25.0	82.0
	13	33.5	109.9
	14	44.9	147.3

Table 1 — Length of Each Segment

Segment Number	Length (Meters)	Length (Feet)
1	1.0	3.3
2	1.3	4.4
3	1.8	5.9
4	2.4	7.9
5	3.2	10.6
6	4.3	14.2
7	5.8	19.0
8	7.8	25.4
9	10.4	34.1
10	13.9	45.7
11	18.7	61.2
12	25.0	82.0
13	33.5	109.9
14	44.9	147.3



Figure 2 — Corner supports of the wires.



Figure 3 — Trees are used for wire support (the antenna is nearly invisible in the trees).



Figure 4 — A 450 to 50 Ω balun.



Figure 5 — Measuring at ground level into the vertical feed wire using a LiteVNA-64. Four short radials were used as a counterpoise.

sleeves can be difficult. For insulators, I repurposed lightweight polycarbonate clothespins with pre-drilled holes by removing the spring ring (see Figure 2). You can thread a 4-millimeter parachute cord through the clothespins to support the corners of the spiral-to-tree (or other) supports, as shown in Figure 3 (because this antenna was set up around a peach tree, the elements are thin and not very visible).

The simulator software I used was *Antenna Model Version 2.0* (it hasn't been available for quite some time now, but I really like using it). I found that even with a relatively rough setup, the antenna works surprisingly well. The feed impedance was determined to be optimal at 450 Ω based on the simulation results, so I

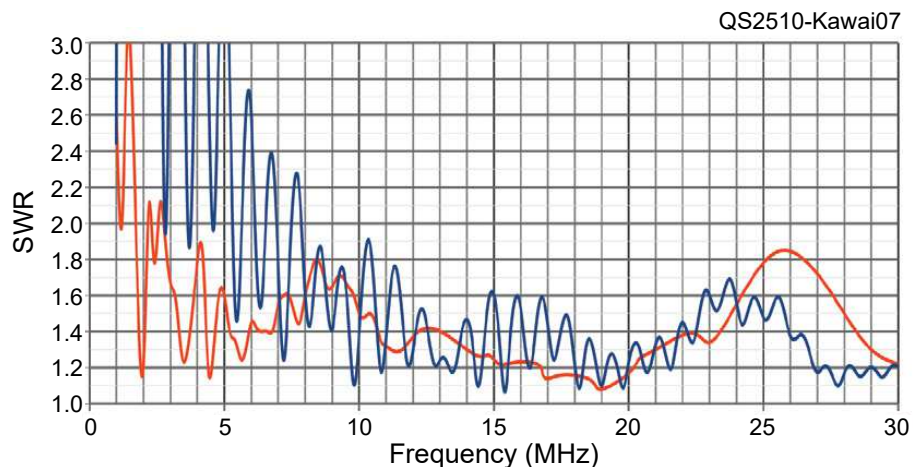


Figure 6 — SWR versus frequency using NEC-simulated (blue curve) and measured values (red curve).

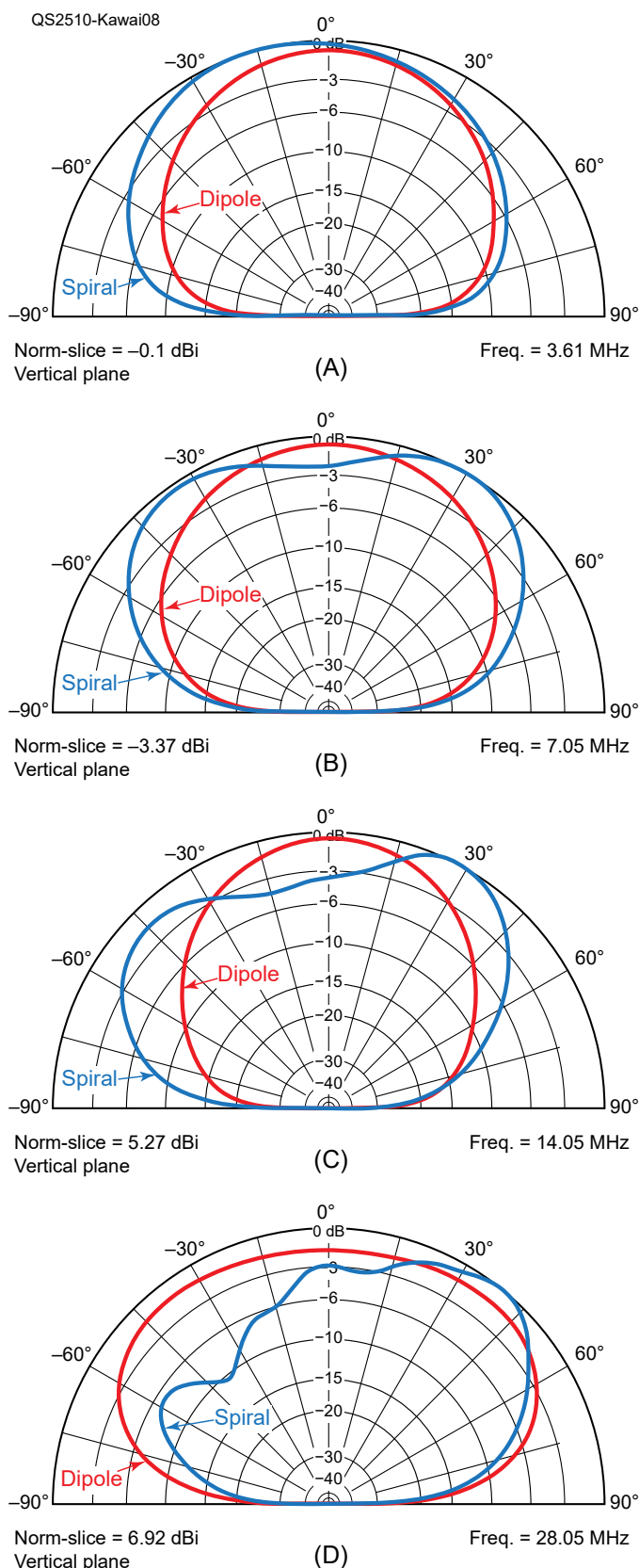


Figure 7 — Patterns of the spiral versus dipole antennas. Both were 10 feet above average ground. The red curve is the dipole, and the blue curve is the spiral. The gains are similar, and the shape of the spiral pattern varies with frequency.

constructed a 9:1 balun. I made a trifilar winding of six turns using 16-AWG (1.25-millimeter) insulated wire on an Amidon FT-114-43 ferrite toroidal core, and it works from 1.8 to 30 MHz (see Figure 4). I used a LiteVNA-64 analyzer for antenna measurements, because it allows screen images and S parameters to be easily saved on a microSD card (see Figure 5).

Measured Results

The measurement results showed a return loss of 10 dB (SWR = 2.0) or better from 1.8 to 28 MHz, making it usable without an antenna tuner. After operating with it for nearly 3 weeks, I concluded that it feels slightly inferior to a dipole antenna. I compared the antenna with a sloping V with a side length of 40 meters, a 3.5 MHz/7 MHz dipole, a 40-meter horizontal loop antenna, and a 14 to 50 MHz wire log-periodic antenna using a six-position antenna switch. Circular polarization was confirmed in the simulation, but I couldn't notice a difference when I used it. Although the height above ground was low (ranging from 5 to 20 feet), it was confirmed to be sufficiently practical.

With a total wire length of 571 feet, this spiral antenna provides very good reception for medium-wave (AM) broadcasts. Through this project, I found that the spiral antenna is worth trying as a wideband antenna. The calculated and measured SWR are shown in Figure 6, and typical patterns are shown in Figure 7.

All photos provided by the author.

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- ✓ NEC files for the antenna
- ✓ More photographs
- ✓ Simulation gain curves versus frequency

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